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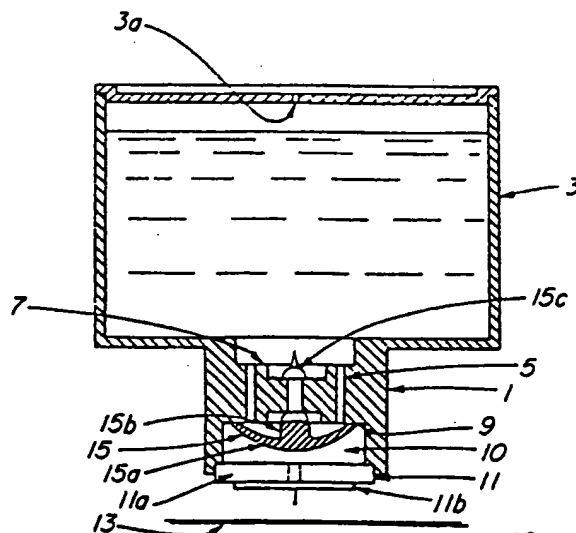
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(54)

Ink jet printhead having a preloaded check valve.

(57)

A preloaded check valve disposed in a valve body between an ink reservoir and a printhead has a valve opening pressure or "cracking" pressure at least sufficient to overcome the hydrostatic pressure due to gravity of ink in the reservoir. This prevents depriming or leakage of ink at the orifices of the orifice plate forming part of the ink ejecting mechanism. Ejection of ink during printing creates a pressure differential across the valve sufficient to cause it to open and replenish the ink supply at the ink ejecting mechanism.



**Fig 1**

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# INK JET PRINTHEAD HAVING A PRELOADED CHECK VALVE

## Technical Field

This invention relates generally to ink jet printheads, and more particularly to an ink jet printhead having an ink reservoir in which provision is made to prevent ink leakage from the orifice plate in normal handling and in use.

## Background Art

Portable or disposable ink jet printheads having attached ink reservoirs require provision to contain the ink during handling as well as in use. Without some provision for containing the ink when the orifice plate is face down, only the surface area mechanics at the orifices operate to contain the ink and this is usually inadequate.

Various techniques for preventing ink leakage at the orifice plate have been proposed. Probably the simplest is to apply a pressure sensitive adhesive tape to the orifice plate to seal the orifice. However, the removal of such tape places the delicate orifice plate at risk to damage and may induce ink leakage at one or more of the orifices. Additionally, the adhesive material if in contact with the orifice plate adjacent to and over the orifices may contaminate the orifices or change the characteristics of the orifice plates sufficiently to degrade print quality.

Foam is also used in the reservoir to retain the ink. Hereagain, surface energy mechanics is a factor in retaining ink in the interstices or the cells in the foam. Pressure reductions when ink is ejected by the ink head are usually sufficient to maintain an uninterrupted ink supply at the orifice plate. Volumetric efficiency however in the use of foam is only about 60 to 65 percent in most applications.

U.S. Patent 4,509,062 entitled "Ink Reservoir With Essentially Constant Negative Back Pressure", issued April 2, 1985 and assigned to the assignee of this invention addresses this problem in an arrangement which maintains a substantially constant negative back pressure slightly greater than the maximum anticipated ink hydrostatic head. This negative back pressure is maintained by the utilization and maintenance of a nonlinear force in an elastic section of the ink reservoir of the printhead.

## Disclosure of the Invention

While the approach of Patent 4,509,062 above offers a viable solution to the problem of ink leakage, an arrangement in accordance with the present invention and providing a positive seal of the ink reservoir is to be preferred. When the reservoir is sealed the hydrostatic head at the orifice plate is reduced. Now only the hydrostatic head of the small ink prime in the cavity between the reservoir and the orifice plate is effective to exert ink pressure at the orifices, significantly reducing the probability of ink leakage thereat.

In implementing this approach to resolving the ink leakage problem, this invention provides a valve body having an opening therethrough. A reservoir is connected to one side of the valve body to supply ink to said opening and a printing substrate assembly comprising a substrate having an orifice plate thereon is sealed to the other end of the valve body defining a small cavity between the substrate and the valve body adjacent the opening. The ink prime is contained in this cavity.

An elastically loaded valve member seals the end of the opening at the cavity. The elastic loading establishes a value of opening pressure of the valve greater than the maximum anticipated hydrostatic pressure due to accelerating forces acting on the ink and the ink reservoir. When the printhead is operated to eject ink, pressure in the ink prime cavity drops. The pressure differential across the valve exceeds the valve opening pressure and the ink is supplied to the ink priming cavity. Thus, a continuous supply of ink is maintained for the printhead while the hydrostatic forces at the orifice plate under quiescent conditions are due only to the hydrostatic head of the ink in the cavity.

## Brief Description of the Drawings

Figure 1 is an enlarged cross sectional view of an ink jet printhead having a valve between an ink reservoir and the print substrate assembly; and

Figure 2 is an enlarged cross sectional view of an ink jet printhead of the type in Figure 1 employing a flexible or limp bladder as the ink reservoir.

### Best Mode For Carrying Out The Invention

Referring to Figure 1, the printhead comprises a valve body 1 having an integrally formed or separately attached rigid ink reservoir 3. Such assemblies are usually molded from a plastic material which has good dimensional stability. In this case such a material may be sufficiently transparent so that the ink level in the reservoir 3 may be visually monitored. Openings 5 formed in the valve body 1, extending between the upper and lower valve body faces 7 and 9, as viewed, provide ink flow between the reservoir 3 and the printing substrate assembly 11. The printing substrate assembly 11 is sealed in the open end of the bottom of the valve body 1 in a position spaced from the lower face 9, defining a small cavity 10 which must be primed with ink for the printing substrate assembly to function properly in ejecting ink to impinge upon paper 13 during a printing operation. Only the relative positions of the printhead body and the paper are shown, it being understood that both the paper and the printhead body are selectively moved in orthogonal paths during a printing operation. The printhead assembly comprises a substrate 11a and an orifice plate 11b. Thermal excitation is used to eject ink. Thermal ink jet printheads are described in the Hewlett Packard Journal, May 1985, Vol. 36, No. 5, beginning on page 4 which material is incorporated herein by reference. The invention is not limited however to this specific type of printhead assembly. The invention is equally useful in applications involving other methods for ejecting the ink.

A valve 15 is employed to control the transfer of ink between the reservoir 3 and the cavity 10. The valve illustrated is a rubber diaphragm type of valve functioning as a check valve to prevent depriming of the cavity 10. It comprises an elastic umbrella shaped diaphragm 15a having a peripheral edge which seats upon the surface 9 and provides a peripheral seal surrounding the openings 5 through the valve body. The valve 15 comprises an integrally formed valve stem having an enlarged base section on the inner side of the umbrella shaped diaphragm and an enlarged end 15c. The enlarged end 15c is forced through a central hole in the valve body, projecting through the upper end as viewed to engage the upper surface of the valve body. The enlarged base section 15b engages the lower face of the valve body. The peripheral edge of the diaphragm is seated and sealed against the surface 9. This deflects the diaphragm 15a and preloads its peripheral edge against the surface 9. In this position, the preloading establishes a valve opening pressure or valve cracking pressure in excess of the hydrostatic pressure resulting at least from the maximum depth of ink in the reservoir 3.

Each time the printing head assembly 11 is fired to eject ink onto the paper 13, the pressure in the cavity is reduced. The diaphragm valve 15 opens replenishing the ink in the priming cavity 10 for that which has been ejected.

The use of the check valve such as the diaphragm valve is advantageous in that the check valve action prevents deprimes. Further, neither the introduction of foam in the reservoir nor the use of the elastic bladder is necessary to prevent gravitationally induced ink leakage through the orifices. Further, there is an easy visual indication of the ink supply in the reservoir if the reservoir has clear body walls.

The use of a rigid reservoir as seen in Figure 1 offers certain advantages in that the ink can be "loose". If the printhead is filled and primed with ink as manufactured, the air hole 3a in the cover may be sealed with a tape which is removed after the printhead is installed in the printing mechanism. Alternatively a check valve may be used for this purpose.

The invention may be practiced with other than a rigid reservoir such as that shown in Figure 1. Figure 2 shows the use of a "limp" bladder 17 installed as the reservoir. The use of the bladder eliminates the need for a tape seal or a check valve on the air return vent 3a, as seen in Figure 1. The limp bladder is sealed to the upper body projection of the valve, in Figure 2, at the time of manufacture.

Only one type of check valve has been illustrated herein. It will be appreciated however, that any type of check valve may be employed which can be preloaded in the closed position. Other typical valves may include, but without limitation, reed valves, spring loaded ball valves, and duck billed valves for example. In all cases, the valve preload derived opening pressure or cracking pressure is chosen to exceed the gravity head by an appropriate safety margin to account for manufacturing tolerances, but not to exceed an opening pressure requirement which would interfere with the ejection of ink when the printhead is fired.

### Industrial Applicability

The invention is applicable in any printhead where depriming or ink leakage must be prevented.

### Claims

1. An inkjet printhead, comprising:
  - a. a valve body having an opening therethrough;

b. an ink supply reservoir connected to said valve body on one side thereof in a position providing an ink supply above said opening for supplying ink by gravity induced flow to said opening;

c. a printhead mounted on said valve body on the other side of said opening in a position spaced from said opening and forming a cavity for receiving ink by gravity induced flow from said opening and ejecting ink for printing; and

d. a valve member sealing said opening, supported within said valve body in said cavity, having an opening pressure greater than the gravitational hydrostatic pressure of ink in said reservoir, and responding to reduced ink pressure in said cavity upon ejection of ink therefrom by said printhead, to open and admit ink to said cavity by gravity induced flow from said reservoir through said opening.

2. The invention according to claim 1, comprising:

a. a face portion surrounding the end of said opening in said cavity, said valve having an umbrella shaped portion of a flexible material terminating in a peripheral edge seated upon said face portion surrounding and sealing said opening.

3. The invention according to claim 1, in which:  
a. said ink supply reservoir comprises a collapsible bladder having an open end sealed to said valve body on said one side thereof for supplying ink by gravity induced flow to said opening.

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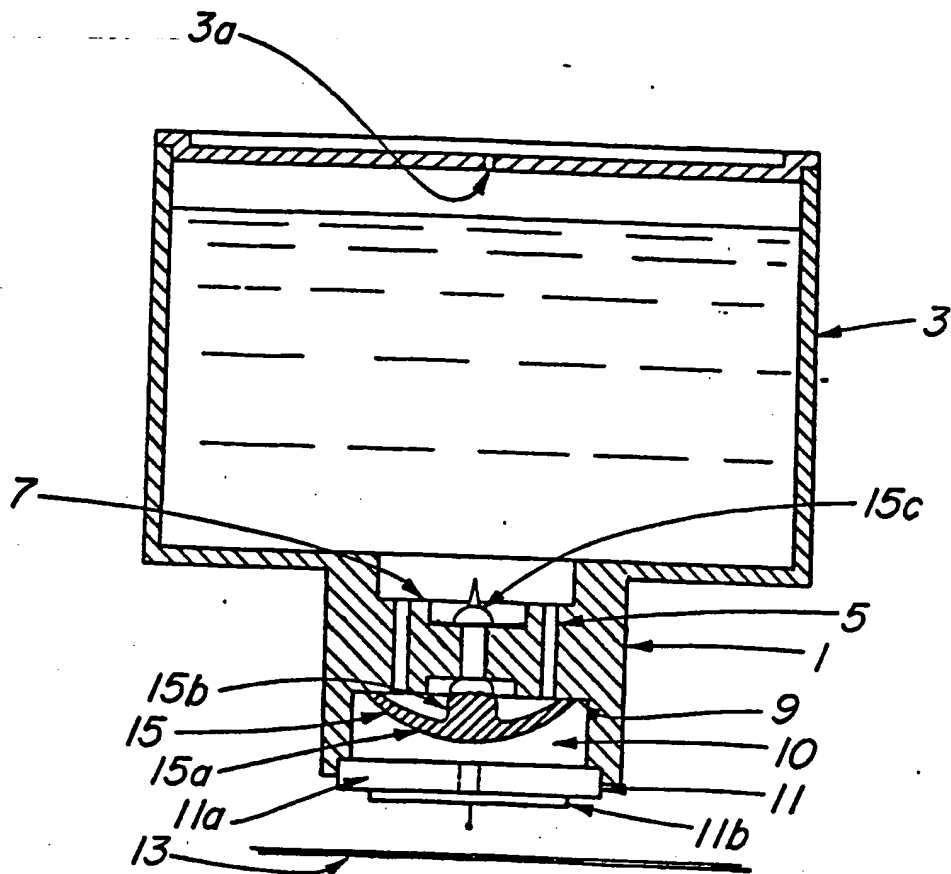
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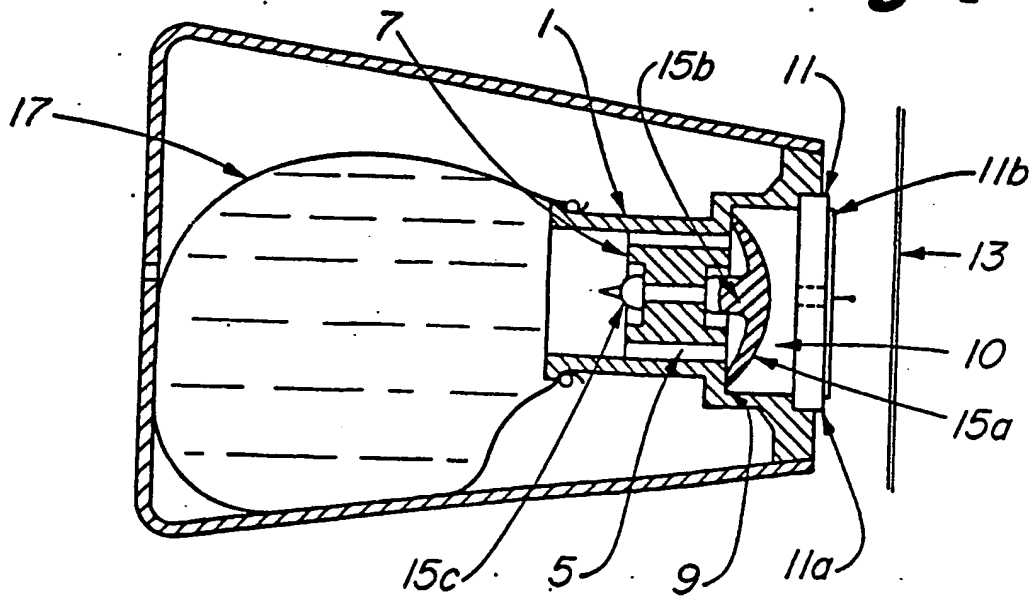
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**Fig 1**



**Fig 2**

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**XEROX DISCLOSURE JOURNAL, vol. 9, No. 2,  
pages 129, 130, March/April 1984, Stamford,  
US; I. REZANKA: "One-way valve for shut-  
down of continuous stream ink jet"**

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## Description

### Technical Field

This invention relates to an ink jet printhead in accordance with the precharacterizing portion of claim 1. Such an ink jet printhead is known from Xerox Disclosure Journal, volume 9, number 2, pages 129 to 130 of March, April 1984.

### Background Art

Portable or disposable ink jet printheads having attached ink reservoirs require provision to contain the ink during handling as well as in use. Without some provision for containing the ink when the orifice plate is face down, only the surface area mechanics at the orifices operate to contain the ink and this is usually inadequate.

Various techniques for preventing ink leakage at the orifice plate have been proposed. Probably the simplest is to apply a pressure sensitive adhesive tape to the orifice plate to seal the orifice. However, the removal of such tape places the delicate orifice plate at risk to damage and may induce ink leakage at one or more of the orifices. Additionally, the adhesive material if in contact with the orifice plate adjacent to and over the orifices may contaminate the orifices or change the characteristics of the orifice plates sufficiently to degrade print quality.

Foam is also used in the reservoir to retain the ink. Hereagain, surface energy mechanics is a factor in retaining ink in the interstices or the cells in the foam. Pressure reductions when ink is ejected by the ink head are usually sufficient to maintain an uninterrupted ink supply at the orifice plate. Volumetric efficiency however in the use of foam is only about 60 to 65 percent in most applications.

U.S.-Patent 4,509,062 entitled "Ink Reservoir With Essentially Constant Negative Back Pressure", issued April 2, 1985 and assigned to the assignee of this invention addresses this problem in an arrangement which maintains a substantially constant negative back pressure slightly greater than the maximum anticipated ink hydrostatic head. This negative back pressure is maintained by the utilization and maintainance of a nonlinear force in an elastic section of the ink reservoir of the printhead.

The ink jet printhead described in the Xerox Disclosure Journal mentioned above includes a main cavity which does not serve as an ink supply reservoir and is connected to a miniature cavity through an opening extending from the main cavity to the orifice. A diaphragm-valve is arranged within the miniature cavity which serves for avoiding air

injection into the cavities of the printhead. At start-up, the diaphragm is opened by the pressure of ink and transmits pressure oscillation about the operating pressure during continuous stream operation and simultaneously serves as an air bubble filter.

It is an object of the invention to provide an ink jet printhead which prevents ink leakage at the orifice plate in an on-off-noncontinuous ink stream operation.

The above object is solved in accordance with the invention by means of the features of claim 1.

The dependent claims 2 and 3 characterize advantageous developments thereof.

In accordance with the present invention a positive seal of the ink reservoir is achieved. When the reservoir is sealed the hydrostatic head at the orifice plate is reduced. Now only the hydrostatic head of the small ink prime in the cavity between the reservoir and the orifice plate is effective to exert ink pressure at the orifices, significantly reducing the probability of ink leakage thereat.

By means of the elastically loaded valve member which seals the end of the opening at the cavity, a value of opening pressure of the valve is greater than the maximum anticipated hydrostatic pressure due to accelerating forces acting on the ink and the ink reservoir. When the printhead is operated to eject ink, pressure in the ink prime cavity drops. The pressure differential across the valve exceeds the valve opening pressure and the ink is supplied to the ink priming cavity. Thus, a continuous supply of ink is maintained for the printhead while the hydrostatic forces at the orifice plate under quiescent conditions are due only to the hydrostatic head of the ink in the cavity.

### Brief Description of the Drawings

Figure 1 is an enlarged cross sectional view of an ink jet printhead having a valve between an ink reservoir and the print substrate assembly; and

Figure 2 is an enlarged cross sectional view of an ink jet printhead of the type in Figure 1 employing a flexible or limp bladder as the ink reservoir.

### Best Mode For Carrying Out The Invention

Referring to Figure 1, the printhead comprises a valve body 1 having an integrally formed or separately attached rigid ink reservoir 3. Such assemblies are usually molded from a plastic material which has good dimensional stability. In this case such a material may be sufficiently transparent so that the ink level in the reservoir 3 may be visually monitored. Openings 5 formed in the valve body 1, extending between the upper and lower valve body

faces 7 and 9, as viewed, provide ink flow between the reservoir 3 and the printing substrate assembly 11. The printing substrate assembly 11 is sealed in the open end of the bottom of the valve body 1 in a position spaced from the lower face 9, defining a small cavity 10 which must be primed with ink for the printing substrate assembly to function properly in ejecting ink to impinge upon paper 13 during a printing operation. Only the relative positions of the printhead body and the paper are shown, it being understood that both the paper and the printhead body are selectively moved in orthogonal paths during a printing operation. The printhead assembly comprises a substrate 11a and an orifice plate 11b. Thermal excitation is used to eject ink. Thermal ink jet printheads are described in the Hewlett Packard Journal, May 1985, Vol. 36, No. 5, beginning on page 4 which material is incorporated herein by reference. The invention is not limited however to this specific type of printhead assembly. The invention is equally useful in applications involving other methods for ejecting the ink.

A valve 15 is employed to control the transfer of ink between the reservoir 3 and the cavity 10. The valve illustrated is a rubber diaphragm type of valve functioning as a check valve to prevent depriming of the cavity 10. It comprises an elastic umbrella shaped diaphragm 15a having a peripheral edge which seats upon the surface 9 and provides a peripheral seal surrounding the openings 5 through the valve body. The valve 15 comprises an integrally formed valve stem having an enlarged base section on the inner side of the umbrella shaped diaphragm and an enlarged end 15c. The enlarged end 15c is forced through a central hole in the valve body, projecting through the upper end as viewed to engage the upper surface of the valve body. The enlarged base section 15b engages the lower face of the valve body. The peripheral edge of the diaphragm is seated and sealed against the surface 9. This deflects the diaphragm 15a and preloads its peripheral edge against the surface 9. In this position, the preloading establishes a valve opening pressure or valve cracking pressure in excess of the hydrostatic pressure resulting at least from the maximum depth of ink in the reservoir 3.

Each time the printing head assembly 11 is fired to eject ink onto the paper 13, the pressure in the cavity is reduced. The diaphragm valve 15 opens replenishing the ink in the priming cavity 10 for that which has been ejected.

The use of the check valve such as the diaphragm valve is advantageous in that the check valve action prevents deprimes. Further, neither the introduction of foam in the reservoir nor the use of the elastic bladder is necessary to prevent gravitationally induced ink leakage through the orifices. Further, there is an easy visual indication of the ink

supply in the reservoir if the reservoir has clear body walls.

The use of a rigid reservoir as seen in Figure 1 offers certain advantages in that the ink can be "loose". If the printhead is filled and primed with ink as manufactured, the air hole 3a in the cover may be sealed with a tape which is removed after the printhead is installed in the printing mechanism. Alternatively a check valve may be used for this purpose.

The invention may be practiced with other than a rigid reservoir such as that shown in Figure 1. Figure 2 shows the use of a "limp" bladder 17 installed as the reservoir. The use of the bladder eliminates the need for a tape seal or a check valve on the air return vent 3a, as seen in Figure 1. The limp bladder is sealed to the upper body projection of the valve, in Figure 2, at the time of manufacture.

Only one type of check valve has been illustrated herein. It will be appreciated however, that any type of check valve may be employed which can be preloaded in the closed position. Other typical valves may include, but without limitation, reed valves, spring loaded ball valves, and duck billed valves for example. In all cases, the valve preload derived opening pressure or cracking pressure is chosen to exceed the gravity head by an appropriate safety margin to account for manufacturing tolerances, but not to exceed an opening pressure requirement which would interfere with the ejection of ink when the printhead is fired.

#### Industrial Applicability

The invention is applicable in any printhead where depriming or ink leakage must be prevented.

#### Claims

1. An ink jet printhead, comprising:
  - a) a valve body (1) having an opening (5) therethrough;
  - b) an ink supply reservoir (3);
  - c) a printhead (11) mounted on the valve body (1) on one side of the opening (5) in a position spaced from said opening and forming a cavity (10) for receiving ink from said opening (5) and ejecting ink for printing, and
  - d) a valve member (15) sealing said opening (5) supported by said valve body (1) in said cavity (10),characterized in that the ink supply reservoir (3) is connected to said valve body (1) on the other side thereof in



a position providing an ink supply above said opening (5) for supplying ink by gravity induced flow to said opening (5),

the valve member (15) has an opening pressure greater than the gravitational hydrostatic pressure of ink in said reservoir (3) and responds to reduced ink pressure in said cavity upon ejection of ink therefrom by said printhead (11) to open and admit ink to said cavity by the gravity induced flow from the reservoir through said opening such that the opening and closing of the valve member (15) is controlled in accordance with the on-off differential pressure that opens the valve member (15) only if a drop of ink is demanded by firing the printhead (11).

2. The ink jet printhead according to claim 1, further characterized by a face portion (9) surrounding the end of said opening in said cavity (10), said valve member (15) having an umbrella shaped portion of a flexible material terminating in a peripheral edge seated upon said face portion (9) surrounding and sealing said opening (5).
3. The ink jet printhead according to claim 1, characterized in that said ink supply reservoir (3) comprises a collapsible bladder (17) having an open end sealed to said valve body (1) on said other side thereof for supplying ink by gravity induced flow to said opening (5).

#### Revendications

1. Une tête d'impression à jet d'encre, comprenant :
  - a) un corps de soupape (1) pourvu d'un orifice (5) le traversant ;
  - b) un réservoir (3) d'alimentation en encre ;
  - c) une tête d'impression (11) montée sur le corps de soupape (1) d'un côté de l'orifice (5) dans une position espacée de ce dernier, et formant une cavité (10) pour recevoir de l'encre provenant dudit orifice (5) et pour éjecter de l'encre pour l'impression, et
  - d) un élément de soupape (15) assurant la fermeture dudit orifice (5) et supporté par ledit corps de soupape (1) dans ladite cavité (10),
 - caractérisée en ce que :
  - le réservoir (3) d'alimentation en encre est relié audit corps de soupape (1) sur son autre côté, dans une position créant une source d'encre au-dessus dudit orifice (5) pour alimenter en encre, s'écoulant par gravité, ledit orifice (5),
  - l'élément de soupape (15) ayant une pression

d'ouverture supérieure à la pression hydrostatique gravitationnelle de l'encre dans ledit réservoir (3) et répondant à une réduction de la pression d'encre dans ladite cavité, lorsque de l'encre est éjectée de celle-ci par ladite tête d'impression (11), pour ouvrir et alimenter ladite cavité en encre s'écoulant à partir du réservoir sous l'effet de la gravité en passant par ledit orifice, de telle sorte que l'ouverture et la fermeture de l'élément de soupape (15) soient commandées en correspondance à la pression différentielle opérant en tout-ou-rien, qui ouvre l'élément de soupape (15) seulement si une goutte d'encre est demandée lors de l'activation de la tête d'impression (11).

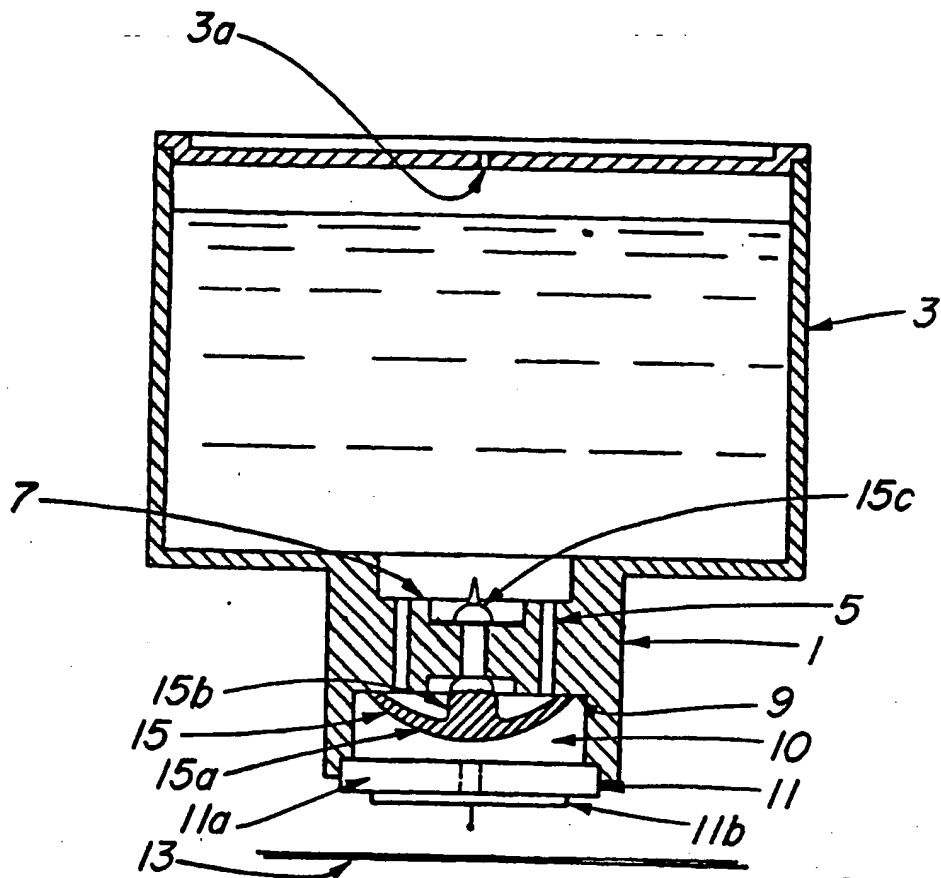
2. La tête d'impression à jet d'encre selon la revendication 1, caractérisée en outre par une surface (9) entourant l'extrémité dudit orifice dans ladite cavité (10), ledit élément de soupape (15) comportant une partie en forme d'ombrelle, constituée d'un matériau flexible et se terminant par un bord périphérique s'appuyant contre ladite surface (9) en entourant ledit orifice (5) et en assurant sa fermeture étanche.
3. La tête d'impression à jet d'encre selon la revendication 1, caractérisée en ce que ledit réservoir (3) d'alimentation en encre comprend une vessie aplatisable (17) comportant une extrémité ouverte scellée sur ledit corps de soupape (1) de l'autre côté de ce dernier pour alimenter ledit orifice (5) en encre s'écoulant par gravité.

#### Ansprüche

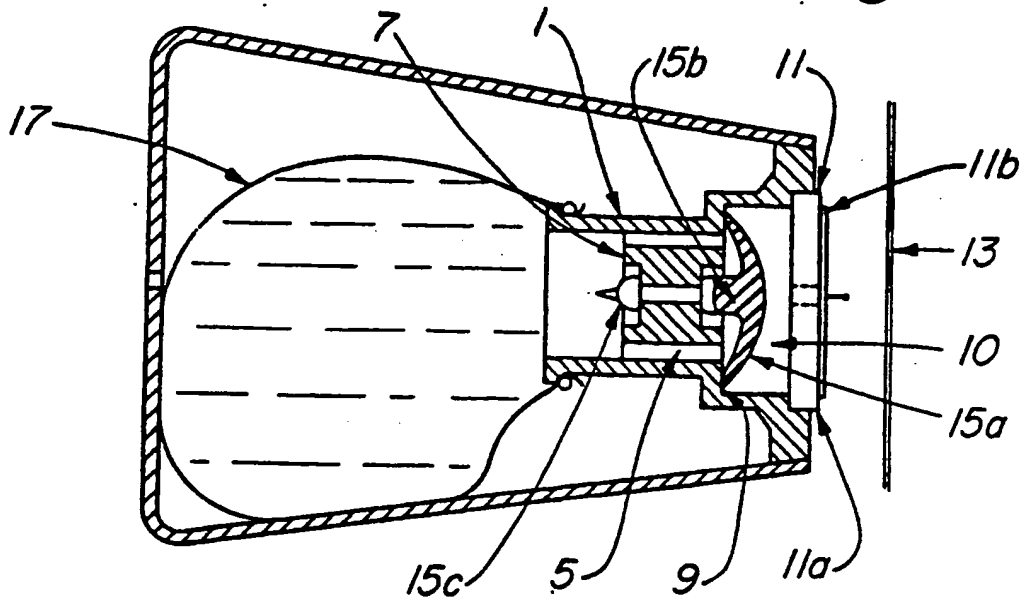
1. Tintenstrahldruckkopf mit:
  - a) einem Ventilkörper (1), der eine hindurchgehende Öffnung (5) hat;
  - b) einem Tintenversorgungsbehälter (3);
  - c) einem Druckkopf (11), der auf dem Ventilkörper (1) an einer Seite der Öffnung (5) in einer von der Öffnung beabstandeten Position befestigt ist und einen Hohlraum (10) bildet, um Tinte aus der Öffnung (5) zu empfangen und beim Druckvorgang auszustoßen, und
  - d) einem die Öffnung (5) abdichtenden Ventiltglied (15), das von dem Ventilkörper (1) in dem Hohlraum (10) gehalten ist, dadurch gekennzeichnet, daß der Tintenversorgungsbehälter (3) mit dem Ventilkörper (1) an dessen anderer Seite in einer Position verbunden ist, die eine Tintenversorgung von oberhalb der Öffnung (5) durch schwerkraftbewirkten Fluß zur Öff-

nung (5) ermöglicht, das Ventilglied (15) einen Öffnungsdruck hat, der größer ist als der durch die Schwerkraft bewirkte hydrostatische Druck der Tinte in dem Behälter (3) und auf verringerten Tintendruck im Hohlraum beim Ausstoßen von Tinte durch den Druckkopf (11) anspricht, sich öffnet und Tinte zum Hohlraum durch den schwerkraftbewirkten Fluß vom Behälter durch die Öffnung durchläßt, so daß das Öffnen und Schließen des Ventilglieds (15) in Übereinstimmung mit dem EINAUS-Differenzdruck gesteuert wird, der das Ventilglied (15) nur öffnet, wenn ein Tintentropfen beim Anschlag des Druckkopfes (11) erforderlich ist.

2. Tintenstrahldruckkopf nach Anspruch 1, weiterhin gekennzeichnet durch einen Stirnteil (9), der das Ende der Öffnung in dem Hohlraum (10) umgibt, wobei das Ventilglied (15) einen schirmförmigen Teil aus einem flexiblen Material hat, der in einer peripheren Kante endet, die auf dem Stirnteil (9) aufsitzt und die Öffnung (5) umgibt und abdichtet.
3. Tintenstrahldruckkopf nach Anspruch 1, dadurch gekennzeichnet, daß der Tintenversorgungsbehälter (3) eine zusammenlegbare Blase (17) aufweist, die ein an der genannten anderen Seite des Ventilkörpers (1) dicht anliegendes offenes Ende aufweist, um Tinte durch schwerkraftbewirkten Fluß zur Öffnung (5) zu speisen.



**Fig 1**



**Fig 2**